Dependence of phytochemical and antioxidant properties of extrudates from a model sorghum-barley blend, on extrusion conditions

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Background

Cereals are valuable for their phytochemicals, which are mainly in the bran and germ, and include anthocyanins, phytosterols, policosanols, carotenoids, and tocopherols[1]. Phytochemicals can affect the colour, flavour and texture of cereal products[2], with concomitant variations in the antioxidant properties. Huang *et al.*[3] discussed the various *in-vitro* assays, mainly electron and hydrogen atom transfer-based, for quantifying antioxidant properties. Phytochemical and antioxidant properties of cereal-based products can be maximised by mixing cereals, but studies are limited in this area, particularly how processing conditions influence these properties. Using twin-screw extrusion, this study investigated a sorghum-barley blend as a model system, and sorghum was chosen because of increasing interests in its food uses, particularly in Australia, where it is mainly an animal feed grain.

Experimental

Extrudates from a mixture of 60% sorghum and 40% barley, produced under different twin-screw extrusion conditions[4]were used, as well as non-extruded sorghum-barley mixtures (0 – 100%). The following phytochemical and antioxidant properties were investigated by spectrophotometry:

- Total anthocyanin content (TAC), using the method in Lopez-Martinez *et al.*[5],with absorbance at 535 nm, and expressed as mg of cyanidin 3-glucoside per kg solids.
- Total phenolic content (TPC), using the Folin-Ciocalteu procedure in Sharma & Gujral[6], with absorbance at 725 nm, and expressed as μg of gallic acid per g solids.
- Radical DPPH^{+} (2,2-diphenyl-1-picrylhydrazyl) scavenging capacity, by the method in Sharma & Gujral[6], with absorbance at 515 nm, and calculated as antioxidant capacity per g solids.
- Radical cation ABTS^{+} scavenging capacity, by the ABTS (2,2''-azinobis(3-ethylbenzothiazoline-6-sulfonic acid)) procedure in Lopez-Martinez *et al.*[5], with absorbance at 734 nm, and expressed in %.
- Ferric reducing antioxidant power (FRAP), by the procedure in Siebenhandl *et al.*[7], with absorbance at 595 nm, and expressed in FRAP values per g solids.

Reagents were of analytical grade, analyses were randomised and duplicated, data were analysed (General Linear Model, GLM) with Minitab(R) ver. 16, and the results from the main effects are presented.

Table 1: Effects of extrusion conditions on the phytochemical and antioxidant properties*

Condition		TAC	TPC	DPPH^{+}	ABTS^{+}	FRAP
Feed †	CM	43^{a}	19^{a}	41^{a}	50^{a}	1140^{a}
	HM	34^{a}	15^{a}	40^{a}	46^{a}	1010^{b}
Moisture (%)	20	29^{a}	13.0^{a}	36^{c}	31^{b}	845^{b}
	25	28^{a}	12.3^{a}	39^{b}	32^{b}	789^{a}
	30	27^{b}	12.5^{a}	36^{c}	35^{a}	798^{a}
	40	30^{a}	12.4^{a}	42^{a}	29^{c}	787^{a}
Screw speed (rpm)	150	29^{a}	12.5^{a}	40^{a}	32^{ab}	809^{a}
	220	28^{a}	12.4^{a}	37^{b}	34^{a}	788^{ab}
	300	28^{a}	12.1^{b}	40^{a}	30^{b}	777^{b}
Tempe-rature (°C)	110	30^{a}	14.2^{a}	36^{a}	38^{a}	870^{a}
	140	29^{a}	12.5^{b}	35^{a}	36^{ab}	804^{a}
	160	31^{a}	11.7^{c}	40^{a}	25^{b}	788^{a}
Feed rate (kgh^{-1})	2	29^{a}	12.5^{b}	35^{b}	36^{a}	804^{b}
	3	32^{a}	12.6^{b}	40^{ab}	38^{a}	855^{a}
	4	26^{a}	13.3^{b}	41^{a}	36^{a}	853^{a}
	5	31^{a}	14.3^{a}	35^{b}	39^{a}	872^{a}

*Values with the same letters are not significantly different ($p>0.05$).
†CM = cryo-mill, and HM = hammer-mill..

Key Findings

Extrusion significantly decreased the phytochemical content and antioxidant properties of the feed. Although hammer-milled (HM) feed was extruded, the cryo-milled feed was included in Table 1 because the extrudates cryo-milled prior to analysis. There were particle size effects on FRAP. Increases in the extrusion temperature, moisture and screw speed did not affect TAC, but TPC was enhanced by increases in the feed rate. Increases in the temperature and screw speed adversely affected TPC because of the supplied and frictional heat. However, both DPPH^{+} and FRAP were independent of the temperature, with the latter being enhanced by the feed rate possibly because more material were available. Moisture appeared to reduce ABTS^{+}. However, as the sorghum content of the non-extrudates increased, TAC increased, TPC was unaffected, and DPPH^{+}, ABTS^{+} and FRAP reduced (Fig. 1). While both the sorghum and barley could have equally contributed to TPC, the red-coloured sorghum had more anthocyanins. Extruding the sorghum-barley mixture at 110°C, 150 rpm and 30% moisture at a feed rate of 5 kg/h will maximise the retention of desirable phytochemicals and antioxidants.

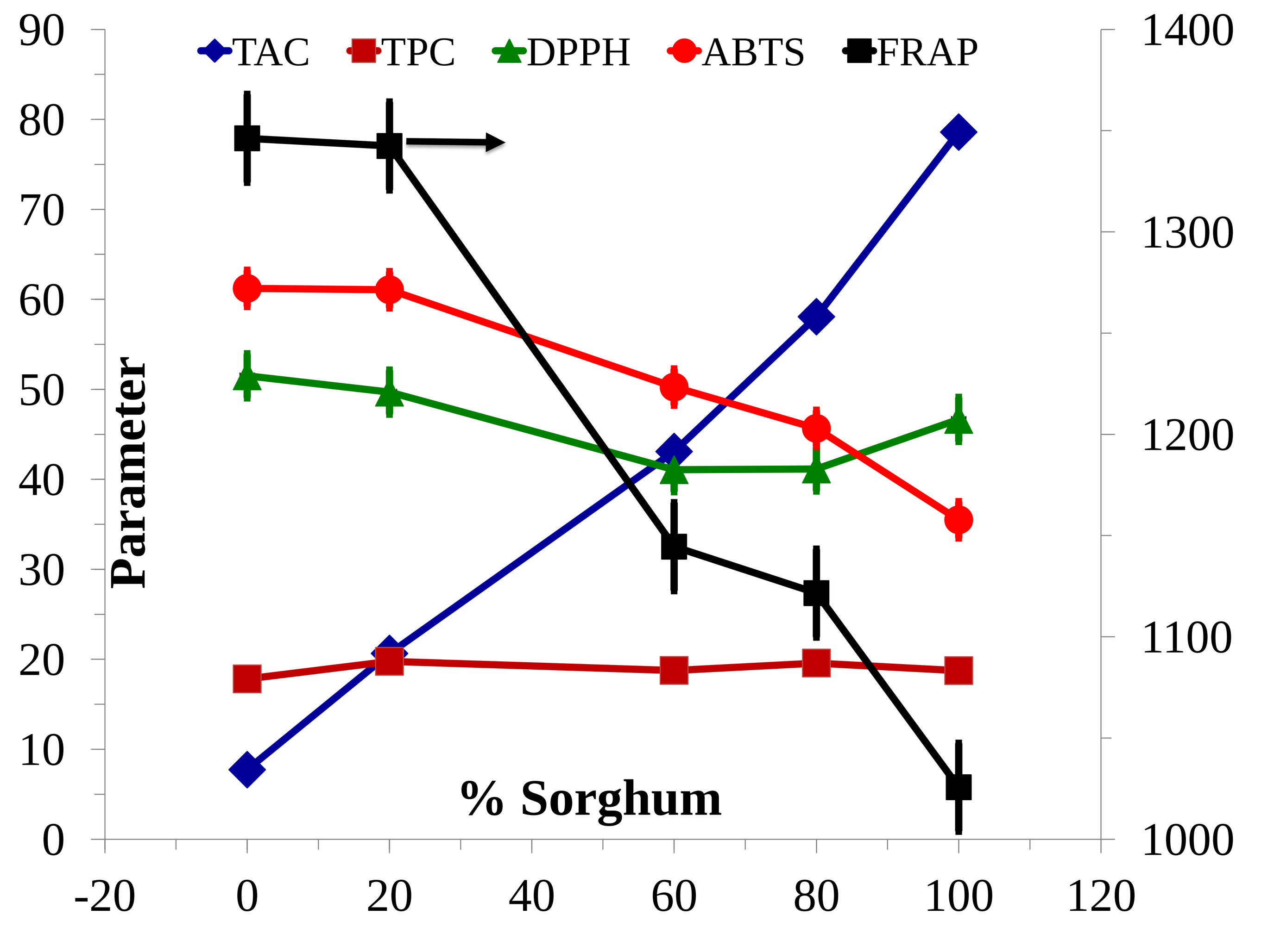

Fig. 1: Phytochemical and antioxidant properties of non-extruded sorghum-barley mixtures

References

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